The Critical Period of Bengal Dayflower (*Commelina Bengalensis*) Control in Peanut

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Bengal dayflower (also known as tropical spiderwort) is one of the most troublesome weeds in peanut in Georgia, United States. Field studies conducted in 2004 and 2005 evaluated the relationship between the duration of Bengal dayflower interference and peanut yield in an effort to optimize the timing of weed control. In 2004, the critical period of weed control (CPWC) necessary to avoid greater than 5% peanut yield loss was between 316 and 607 growing degree days (GDD), which corresponded to an interval between June 8 and July 2. In 2005, the CPWC ranged from 185 to 547 GDD, an interval between May 30 and July 3. Maximum yield loss in 2005 from season-long interference of Bengal dayflower was 51%. In 2004, production of peanut pods was eliminated by interference with Bengal dayflower for the initial 6 wk (495 GDD) of the growing season. Robust Bengal dayflower growth in 2004 shaded the peanut crop, likely intercepting fungicide applications and causing a reduction in peanut yield. Therefore, the competitive effects of Bengal dayflower are likely complicated with the activity of plant pathogens. In spite of higher Bengal dayflower population densities, greater Bengal dayflower growth, and greater peanut yield losses in 2004 than in 2005, the CPWC was a relatively similar 4-wk period that ended during the first week of July, for peanut that was planted in the first week of May.

Nomenclature: Bengal dayflower (tropical spiderwort), *Commelina Bengalensis* L. COMBE; peanut, *Arachis hypogaea* L.

Key words: Competition, noxious weed, interference, invasive weed, yield loss.

Bengal dayflower (also known as tropical spiderwort) is a significant weed throughout warm temperate regions of Africa, Asia, and South America (Holm et al. 1977; Webster et al. 2005a; Wilson 1981). This exotic invasive weed has become a significant pest in cotton (*Gossypium hirsutum* L.) and peanut in Georgia and Florida (Webster 2005). With a known distribution limited to five Georgia counties in 1999, Bengal dayflower was confirmed in 29 Georgia counties in 2004 (Prostko et al. 2005b), with four more added in 2005 (Flanders 2005) and three more counties in 2006 (A. S. Culpepper, personal communication). Bengal dayflower has become a significant pest because of drastic changes in crop production practices, including, but not limited to: elimination of the use of preemergence (PRE) herbicides with soil residual activity, adoption of reduced tillage (coupled with elimination of cultivation as a weed control tactic), and reliance on glyphosate-based systems for weed control (Brecke et al. 2005; Spader and Vidal 2000; Webster et al. 2005a, 2006). Although glyphosate-based cropping systems have provided more efficient weed control, there are several weeds that are not effectively managed with these systems (Main et al. 2004; Mueller et al. 2005). Bengal dayflower is an example of a species that became problematic when glyphosate was relied upon as the primary means of weed control. Control of 3 to 10–cm-tall Bengal dayflower plants with glyphosate was ineffective ($<$ 55% control) (Culpepper et al. 2004). Poor control of Bengal dayflower in cotton has an impact on subsequent rotational crops such as peanut. Another consideration for Bengal dayflower control is that this weed species is an alternate host for several soil-borne plant pathogens and nematodes, which could have a deleterious impact on crop rotations aimed at reducing these pests (Davis et al. 2006; Desaeger and Rao 2000; Kucharek et al. 1998; Mbwana et al. 1995; Narendra and Rao 1973).

Bengal dayflower possesses a sprawling growth habit that will quickly form a dense ground cover capable of developing adventitious roots at nodes upon soil contact (Webster et al. 2005a). Previous studies indicated that Bengal dayflower was more competitive than peanut when grown in replacement series studies in the greenhouse (Chivinge and Kawisi 1990). When Bengal dayflower was a component of a multispecies weed complex, cotton and peanut yields were reduced up to 62% (Ahanchede 1996; Paulo et al. 2001). However, no studies thus far have evaluated the effect of duration of Bengal dayflower interference on peanut in the absence of other weeds. Determination of the critical period of weed control (CPWC) has been advocated as an important means of timing postemergence (POST) weed management, especially in herbicide-tolerant crops (Knezevic et al. 2002, 2003; Martin et al. 2001). However, understanding the CPWC for a particular species can also aid in development of multiple-tactic weed management systems. For instance, planting cotton in April, as opposed to June, is a means of reducing the impact of Bengal dayflower on cotton yield (Webster et al. 2005b). Because of the occurrence of tomato spotted wilt virus, peanut is at it lowest risk for infection when planted between May 11 and May 31 (Culbreath 2007). Therefore, early planting cannot be used as a strategy to avoid the situation in which young crop seedlings will be competing for resources during primary Bengal dayflower emergence and growth periods. In peanut, weed management systems rely on multiple herbicide applications.

The objective of this study was to quantify the critical period of Bengal dayflower control in peanut in order to optimize the timing of weed control and provide guidance on the length of residual herbicide control required to minimize the impact of Bengal dayflower.

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Materials and Methods

Field studies were conducted in 2004 and 2005 in a grower's field with a naturalized population of Bengal dayflower near Cairo in Grady County, GA. The soil type was Varina sandy loam (fine, kaolinitic, thermic Plinthic Paleudults) with 0.5% organic matter and soil pH 6.0 to 6.2. Fields were conventionally prepared by harrowing. Peanut (Georgia Green) was planted May 5, 2004 and May 7, 2005 at a rate of 19 seed m^{-1} in rows spaced 91 cm apart. The entire experimental area was treated with 930 g ai ha^{-1} pendimethalin immediately following planting in order to minimize presence of grass and small-seeded broadleaf weeds. Previous studies indicated that pendimethalin has no affect on Bengal dayflower growth (A. S. Culpepper, personal communication). Plots consisted of four rows, each 7.6 m in length. Treatments were arranged in a randomized complete block design and replicated four times. Weedy duration and weed-free duration intervals included 0, 2, 4, 6, 8, and 10 wk after peanut emergence (WAE) in 2004 and 0, 2, 3, 4, 5, and 7 WAE in 2005. The weedy duration interval was defined as the length of time that Bengal dayflower competed with peanut beginning at crop emergence. Following this interval, Bengal dayflower was kept out of these plots until 11 WAE in 2004 and 8 WAE in 2005, the time during which emergence of new Bengal dayflower plants was negligible. The weed-free duration interval was defined as the length of time, measured from peanut emergence, that Bengal dayflower was kept out of the plot. Following this interval, Bengal dayflower reinfested the plot and competed with peanut until harvest. All prescribed weed-free intervals were maintained by hand-weeding and hoeing. To prevent reestablishment of large Bengal dayflower plants, their biomass was removed from the plot following weeding.

The grower applied maintenance fungicides to the experimental plots when the rest of the field (commercial operation) was treated, according to University of Georgia Extension recommendations (Prostko et al. 2005a). In 2005, clethodim at 0.14 kg ai ha^{-1} was applied to the entire experimental area to control grasses, because of the lack of timely rainfall to fully activate the pendimethalin. Low densities ($<$ 0.1 plants m^{-2}) of eclipta (*Eclipta prostrata* L.) in 2004 and of spiny amaranth (*Amaranthus spinosus* L.) in 2005 were hand weeded in all plots as needed; however, the aggressive growth of Bengal dayflower minimized growth of other weed species.

Peanut plant canopy width was measured at 3, 5, 7, and 9 WAE. Bengal dayflower emergence data were collected every 7 d in the weed-free control until crop canopy formation. Newly emerged weeds were quantified in four 0.25-m^2 quadrats in each replication prior to removal. Rainfall data were collected at each site and measured weekly. Soil temperature data (2-cm depth) used for growing-degree-day calculation were collected off-site at the Georgia Weather Monitoring Network, located within 5 km of the experiment (Hoogenboom 2006). Growing degree days were calculated by using daily minimum and maximum soil temperature and a model that uses a modified sine wave (Allen 1976). Previous studies used a base temperature of 15.5 C for Bengal dayflower (Webster et al. 2004), in part because of the widespread use of this base temperature in tracking the phenological stages in cotton production (Viator et al. 2005); growing-degree models are not commonly used in peanut.

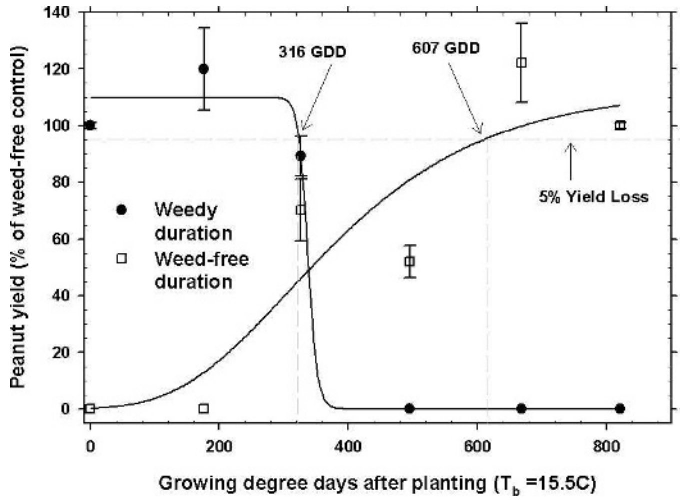

Figure 1. The relationship between duration of Bengal dayflower interference and peanut yield in 2004. The weedy duration study was described by log-logistic regression model $y = 110/[1 + (x/329)^{47}]$, $P < 0.0001$. The weed-free duration study was described by the Gompertz regression model $y = 111.2 \exp\{-\exp[-(x - 300)/166]\}$, $P < 0.0001$. The horizontal dashed line represents 5% yield loss relative to the weed-free control, and the vertical dashed lines define the critical period of weed control of 316 and 607 growing degree days (base temperature of 15.5 C).

However, in order to improve the applicability of these data to growers (Forcella 1997), the use of growing degree days is recommended to describe CPWC because it provides a more biologically meaningful measure of crop growth compared to just time after planting (Knezevic et al. 2002). The selection of this base temperature for Bengal dayflower was guided by previous research (Gonzalez and Haddad 1995; Walker and Evenson 1985b). Each of the four different types of Bengal dayflower seed (large aerial, small aerial, large subterranean, and small subterranean) were evaluated for their response to temperatures between 15 and 36 C. Small seeds failed to germinate at 15 C, but germination did occur at the next highest temperature evaluated (18 C) (Walker and Evenson 1985b). Small aerial seeds account for 73 to 79% of total seed production (Walker and Evenson 1985a).

The crop was inverted approximately 5 d prior to harvest. Peanut yield was determined from two rows of each plot with the use of a stationary plot thresher on October 1, 2004 and November 1, 2005. Data were subjected to analysis of variance with the use of a mixed model in which weedy and weed-free duration were fixed effects and replications were random effects, as described by Knezevic et al. (2002). The relationship between crop yield and growing degree days in the weedy duration and weed-free duration studies were fit to a logistic regression model and a Gompertz regression model, respectively.

Results and Discussion

Weedy Duration. There were significant treatment by year interactions for peanut yield; therefore, data were presented separately for 2004 and 2005. In 2004, there was no effect of Bengal dayflower interference on peanut yield reduction for the initial 2 wk of the growing season (Figure 1). There was a 10% yield reduction when Bengal dayflower interfered with peanut for the initial 4 wk of the growing season (326 GDD) following peanut emergence. Across 6 site years, sicklepod

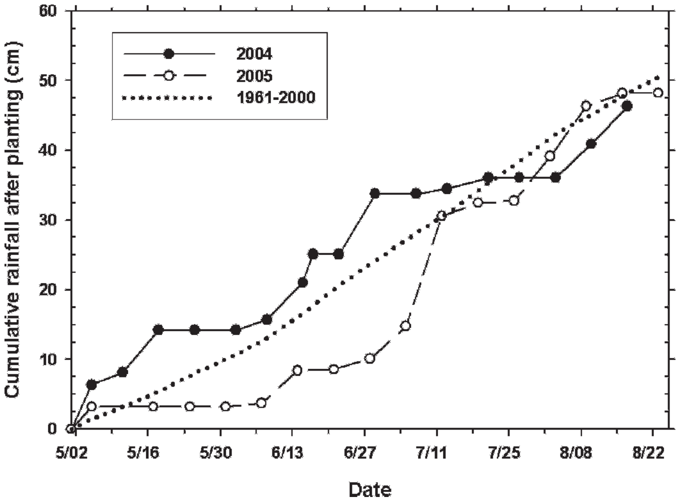

Figure 2. Cumulative rainfall during the growing season in 2004 and 2005 at the Tenewitz Farm and the 40-yr average rainfall for Grady County, Georgia, United States (Hoogenboom 2006).

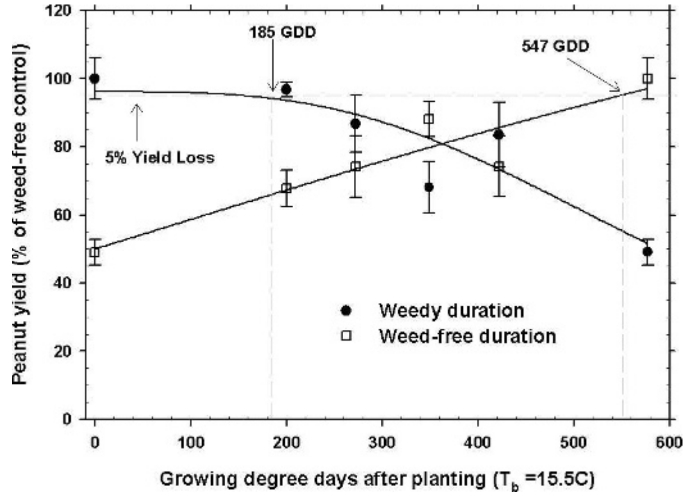

Figure 3. The relationship between duration of Bengal dayflower interference and peanut yield in 2005. The weedy duration study was described by log-logistic regression model $y = 100/[1 + (x/602)^{2.5}]$, $P = 0.0001$, and the weed-free duration study was described by the Gompertz regression model $y = 152 \exp\{-\exp[-(x - 67)/635]\}$, $P = 0.0002$. The horizontal dashed line represents 5% yield loss relative to the weed-free control, and the vertical dashed lines define the critical period of weed control of 185 and 547 growing degree days (base temperature of 15.5 C).

[*Senna obtusifolia* (L.) Irwin and Barneby] interference for 6 wk caused up to 13% peanut yield loss (Hauser et al. 1975). Similarly, 6 wk of interference from common cocklebur (*Xanthium strumarium* L.) reduced peanut yield 14% (Royal et al. 1997a), whereas this duration of interference from bristly starbur (*Acanthospermum hispidum* DC.) reduced peanut yield 17 to 23% (Walker et al. 1989). Horsenettle (*Solanum carolinense* L.) reduced peanut yield 14% when interfering with peanut growth for the initial 6 wk of the season (Hackett et al. 1987). Six wk of interference from Bengal dayflower (495 GDD) eliminated peanut pod production (100% reduction in yield) in 2004. The field site in 2004 had a very high naturalized population of Bengal dayflower; over the course of the season, 1,080 Bengal dayflower plants m^{-2} emerged in the weed-free control. Adequate early-season rainfall in 2004 allowed for robust Bengal dayflower growth (Figure 2). Bengal dayflower plants exceeded the height of the peanut crop, forming a canopy by 5 wk after planting in 2004 (personal observation). The aggressive growth and high Bengal dayflower plant densities in 2004 minimized peanut growth. However, not all of the yield loss can be attributed to Bengal dayflower interference. One consequence of Bengal dayflower forming a canopy above the peanut was the interception of maintenance fungicide applications (personal observation), a situation that has been previously documented with broadleaf weeds in peanut (Royal et al. 1997b). Therefore, peanut yield loss was confounded in 2004, as yield loss could be attributed to both Bengal dayflower interference and plant pathogens, because of the inability of fungicides to contact peanut foliage.

In 2005, peanut yield loss from Bengal dayflower was not as severe as that observed in 2004. Maximum yield loss from season-long Bengal dayflower interference was 51% in 2005, and 2 wk of interference at the beginning of the season reduced yields $< 5\%$ (Figure 3). Season-long interference ($>$ 18 wk) from Florida beggarweed [*Desmodium tortuosum* (Schwartz) DC.] and horsenettle caused 39% peanut yield loss, and sicklepod reduced peanut yields 38 to 75% (Hackett et al. 1987; Hauser et al. 1975). Peanut yield loss from season-long interference from wild poinsettia (*Euphorbia heterophylla* L.) ranged between 75 and 82%, and common cocklebur reduced yields 85% (Bridges et al. 1992; Royal et al. 1997a).

Differences in peanut yield losses due to Bengal dayflower intervals of interference among years are likely related to the site and environmental characteristics. Although both sites were on the same farm and had naturalized Bengal dayflower populations, the total number of plants that emerged in the 2005 weed-free control (230 Bengal dayflower m^{-2}) was approximately one-fourth of the emerged population in 2004. The overriding environmental characteristic that likely limited Bengal dayflower emergence was rainfall. Rainfall immediately prior to planting in 2005 totaled 3.2 cm; however, the subsequent 3 wk had no measurable rainfall (Figure 2). Early-season lack of moisture in this nonirrigated field affected early-season peanut growth and Bengal dayflower emergence. In its native habitat, Bengal dayflower is characterized as a monsoon weed, responding to high soil moisture with rapid emergence, growth, and reproduction (Kaul et al. 2002). Significant rainfall events in late June and early July of 2005 brought the cumulative rainfall totals in 2004 and 2005 to similar levels. Temperature is the other environmental factor governing weed emergence; however, accumulation of growing degree days was similar in 2004 and 2005 (data not shown).

Weed-Free Duration. Peanut yield increased with weed-free duration in a sigmoidal manner in 2004 ($P < 0.0001$), and in a near-linear manner in 2005 ($P = 0.0002$). When peanuts were maintained free of Bengal dayflower for only the initial 2 wk of the growing season (after which Bengal dayflower was allowed to emerge and interfere with peanut for the remainder of the season), peanut yield was eliminated in 2004 (Figure 1). Plots kept free of Bengal dayflower for only the first 6 wk of the growing season reduced peanut yields to $< 70\%$ of the weed-free control. When Bengal dayflower was eliminated during the initial 8 wk of the growing season (668 GDD), there was no detectable peanut yield loss relative to the weed-free control in 2004.

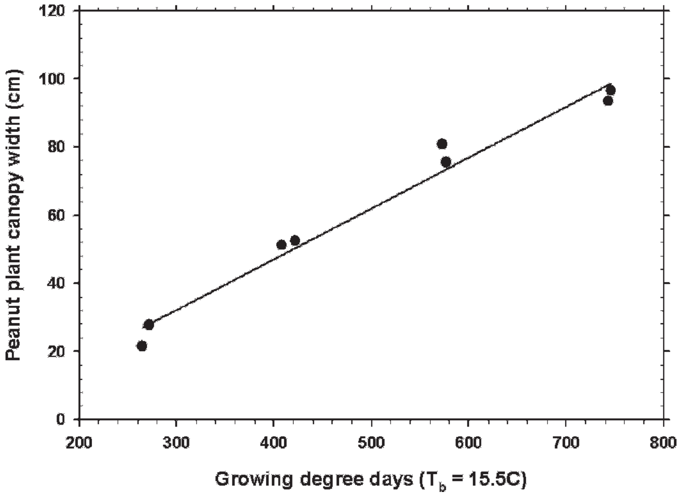

Figure 4. The linear relationship between peanut canopy width and growing degree days, with a base temperature of 15.5 C. $y = 0.1492x - 12.57$, $R^2 = 0.92$, $P < 0.0001$.

The lack of high Bengal dayflower densities in 2005 relative to 2004 resulted in different patterns in peanut yield loss due to weed interference. The drought-like conditions at the beginning of the 2005 growing season minimized the benefit of early-season weed control due to the lack of Bengal dayflower emergence. When peanut was kept free of Bengal dayflower for the first 2 to 5 wk following peanut emergence (200 to 422 GDD), peanut yield ranged from 68 to 88% of the yield in the weed-free treatment (Figure 3).

Common cocklebur controlled only during the initial 2 to 6 wk of the growing season resulted in peanut yields that were 46 to 82% of the weed-free control (Royal et al. 1997a). A 2-wk weed-free period for wild poinsettia reduced peanut yields 17 to 56%, and a 6-wk weed-free period resulted in 13 to 39% peanut yield loss (Bridges et al. 1992). When allowed to reinfest after 2 wk of weed-free conditions, bristly starbur and horsenettle reduced peanut yields 19 to 28 and 10%, respectively (Hackett et al. 1987; Walker et al. 1989). In these same studies, 6 wk of weed-free conditions averted a peanut yield loss due to bristly starbur and caused 5% yield loss from horsenettle.

Critical Period of Weed Control. Metolachlor is an effective residual control of Bengal dayflower (Culpepper et al. 2004; Prostko et al. 2005b; Webster et al. 2006). As peanut emerges, it is recommended that me-
tolachlor (0.80 kg ai ha^{-1}) be applied with bentazon (0.28 kg ai ha^{-1}), and paraquat (0.21 kg ai ha^{-1}) to control emerged and germinating Bengal dayflower seedlings (Prostko et al. 2005b). A sequential application of imazapic (0.070 kg ha^{-1}) and metolachlor (0.80 kg ha^{-1}) is recommended POST. The cost of this program is $99/ha, which is approximately equivalent to 5% peanut yield loss (assuming a yield of 4480 kg ha^{-1} and a selling price of $0.46 kg^{-1}). The Bengal dayflower CPWC necessary to avoid greater than 5% peanut yield loss in 2004 was an interval between 316 and 607 growing degree days (GDD), corresponding to a 24-d period between 3 (June 8) and 7 wk (July 2) after peanut emergence (Figure 1). During this interval, the predicted peanut canopy width was 35 to 78 cm (Figure 4). In 2005, the CPWC ranged from 185 to 547 GDD, a 34-d interval between May 30 and July 3. The peanut canopy width at the initiation of the CPWC in 2005 was estimated to be < 27 cm, whereas at the end of this interval, it was 69 cm (Figure 4). In both seasons, the estimated CPWC coincided with active Bengal dayflower emergence periods, with maximum weekly emergence rates of 311 and 63 plants m^{-2} in 2004 and 2005, respectively (Figure 5).

The point at which the regression for weedy duration and weed-free duration intersect represents the minimum yield loss that can be expected from an optimally timed single

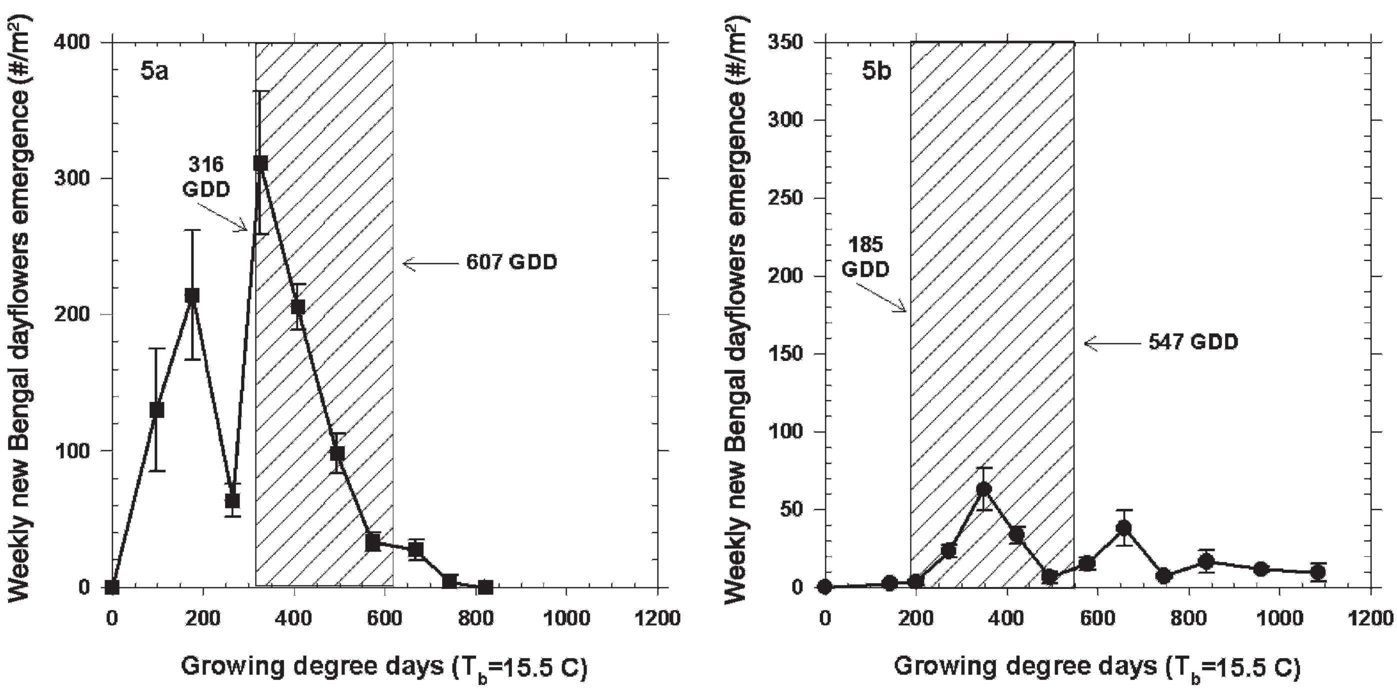

Figure 5. The influence of growing degree days (base temperature of 15.5 C) on weekly Bengal dayflower emergence. Periods of active Bengal dayflower emergence in both 2004 (a) and 2005 (b) occurred within the critical period of weed control intervals defined in Figures 1 and 3, which are indicated by the hatched boxes.

weed control action. The aggressive growth of Bengal dayflower in 2004 is illustrated by an intersection point representing 46% yield loss if a weed control action occurs at 354 GDD (Figure 1). In contrast, the intersection point in 2005 represents 19% yield loss if weed control is initiated at 374 GDD (Figure 3). The inclusion of herbicides with soil residual activity (i.e., metolachlor and imazapic) is necessary for effective management of Bengal dayflower in peanut.

To minimize the impact of Bengal dayflower on peanut, growers need to maintain their peanut crop free of Bengal dayflower between 3 and 7 wk after peanut emergence. This CPWC interval does not occur as early in the growing season and does not last as long as that found in a study conducted in Brazil. In a mixed population of weeds that included Bengal dayflower and various grass and dicot weeds, peanut required a CPWC interval of 2 to 9.5 wk after crop planting (Paulo et al. 2001). The results of the current study are consistent with previous research of CPWC with other weeds in peanut. The CPWC for bristly starbur and horsenettle in peanut was between 2 and 6 wk after crop emergence (Hackett et al. 1987; Walker et al. 1989). Common cocklebur was a competitive species, requiring a CPWC interval between 2 and 12 wk after crop emergence (Royal et al. 1997a). The CPWC for wild poinsettia was estimated to begin between 1.5 and 5 wk after crop emergence and to last between 7 and 12 wk in duration (Bridges et al. 1992). There is great variability in the CPWC among the weed species, which may reflect differences in competitive abilities among the tested weed species and peanut varieties. However, peanut yield was measured after season-long interference from horsenettle, common cocklebur, and wild poinsettia. In contrast, Bengal dayflower interference with peanut for 6 wk prevented peanut yield in 1 of 2 yr of the current study. Walker et al. (1989) reported that 20-wk (season-long) bristly starbur interference caused 100% peanut yield loss in 1 of 3 yr.

One potential problem with CPWC studies is the methodology used to maintain the weed-free periods. In the current study, the prescribed areas were hand weeded weekly. With a prostrate crop like peanut that sets fruiting branches that peg to subterranean positions, excessive hoeing and soil movement can result in crop injury, potentially introducing variability into crop yield. Combining the peanut growth habit with a sprawling plant such as Bengal dayflower, which forms adventitious roots at nodes in contact with the soil, can make effective weed removal problematic. Small Bengal dayflower plants were easily uprooted with minimal disturbance. However, removal of dense mats of Bengal dayflower vegetation between crop rows late in the growing season required significant soil disturbance. Previous researchers have utilized two primary techniques for removing weeds in CPWC studies: hand weeding/hand hoeing (Bridges et al. 1992; Burnside et al. 1998; Halford et al. 2001; Harker et al. 2001; Lopez-Ovejero et al. 2005; Ngouajio et al. 1997; Norsworthy and Oliveira 2004; Walker et al. 1989) and combinations of herbicide and hand-hoeing (Baziramakenga and Leroux 1994; Farris et al. 2005; Zhang et al. 2003). Others have evaluated the weedy duration using only herbicides (Knezevic et al. 2003), whereas other studies on weed-free durations relied on hand-weeding and hoeing (Buchanan and Hauser 1980; Hauser et al. 1975) or combinations of hand weeding and cultivation (Buchanan et al. 1976). Finding the most effective means of removing the weed from the crop while minimizing the effect on crop yield is an issue that must be addressed. Plots treated with herbicides at different time intervals (and different crop growth stages) may affect CPWC intervals; however, physical weed control (e.g., hand removal, hoeing, and cultivation) can have the same effects. In addition, although physical weed control will immediately halt weed interference, weeds treated with herbicides may continue to interfere with crop growth for several days following treatment (Earl et al. 2004; Ferrell et al. 2003, 2004). Therefore, herbicide mode of action may need to be considered in order to adjust CPWC intervals that were determined using physical weed control appropriately. Ultimately, because of the increased adoption of conservation tillage and increasing costs (both labor and fuel) associated with in-crop cultivation (physical weed control), it is likely that growers will use CPWC intervals as a means to optimize herbicide applications. Future studies may need to address these issues in order to improve applicability to growers' fields of CPWC information generated by these types of studies.

In summary, Bengal dayflower poses a serious threat to peanut production where it occurs. Season-long interference of Bengal dayflower in 2005 was 51%. However, peanut yield was eliminated by interference with Bengal dayflower for the initial 6 wk (495 GDD) of the 2004 growing season. The Bengal dayflower CPWC necessary to avoid greater than 5% peanut yield loss was between 316 and 607 GDD in 2004 and 185 to 547 GDD in 2005. These intervals indicate that multiple herbicide applications are likely necessary to minimize Bengal dayflower impact on peanut yield. Application of the CPWC will maximize the effectiveness of weed control tactics in terms of the benefit on crop yield in a particular season. However, there are instances when rigorous Bengal dayflower control programs should be employed. Aggressive control of Bengal dayflower must be instituted in newly infested areas. The key to minimizing the impact of this weed in newly invaded areas in the Southern and potentially the Midwestern United States is to eradicate Bengal dayflower in locales outside of Florida and southern Georgia.

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Literature Cited

Ahanchede, A. 1996. Agronomic impacts of the dispersal of two morphological types of *Commelina Bengalensis* L. in Benin. Pages 75–82 *in* Proceedings of the 10th International Symposium on the Biology of Weeds, Dijon, France.

Allen, J.C. 1976. A modified sine wave method for calculating degree days. Environ. Entomol. 5:388–396.

Baziramakenga, R. and G.D. Leroux. 1994. Critical period of quackgrass (*Elytrigia repens*) removal in potatoes (*Solanum tuberosum*). Weed Sci. 42:528–533.

Brecke, B.J., D.O. Stephenson, and K. Hutto. 2005. Impact of tillage and herbicides on tropical spiderwort. *In* Proceedings of the Tropical Spiderwort Symposium, Tifton, GA, November 29, 2005. http://www.cropsoil.uga.edu/weedsci/tsw2005/index.html. Accessed: February 14, 2007.

Bridges, D.C., B.J. Brecke, and J.C. Barbour. 1992. Wild poinsettia (*Euphorbia heterophylla*) interference with peanut (*Arachis hypogaea*). Weed Sci. 40:37–42.
Buchanan, G.A. and E.W. Hauser. 1980. Influence of row spacing on competitiveness and yield of peanuts (*Arachis hypogaea*). Weed Sci. 28:401–409.
Buchanan, G.A., E.W. Hauser, W.J. Ethridge, and S.R. Cecil. 1976. Competition of Florida beggarweed and sicklepod with peanuts. II. Effects of cultivation, weeds, and SADH. Weed Sci. 24:29–39.
Burnside, O.C., M.J. Wiens, B.J. Holder, S. Weisberg, E.A. Ristau, M.M. Johnson, and J.H. Cameron. 1998. Critical periods for weed control in dry beans (*Phaseolus vulgaris*). Weed Sci. 46:301–306.
Chivinge, O.A. and M. Kawisi. 1990. Effects of intra- and inter-specific competition on the growth and development of wandering jew (*Commelina Bengalensis* L.) and groundnuts (*Arachis hypogaea* L.). Zimb. J. Agric. Res. 28:75–82.
Culbreath, A.K. 2007. University of Georgia: Tomato Spotted Wilt Virus. www.tomatospottedwiltinfo.org/peanut/default.htm. Accessed: February 26, 2007.
Culpepper, A.S., J.T. Flanders, A.C. York, and T.M. Webster. 2004. Tropical spiderwort (*Commelina Bengalensis*) control in glyphosate-resistant cotton. Weed Technol. 18:432–436.
Davis, R.F., T.M. Webster, and T.B. Brenneman. 2006. Host status of tropical spiderwort (*Commelina Bengalensis*) for nematodes. Weed Sci. 54:1137–1141.
Desaeger, J. and M.R. Rao. 2000. Parasitic nematode populations in natural fallows and improved cover crops and their effects on subsequent crops in Kenya. Field Crops Res. 65:41–56.
Earl, H.J., J.A. Ferrell, W.K. Vencill, M.W. van Iersel, and M.A. Czarnota. 2004. Effects of three herbicides on whole-plant carbon fixation and water use by yellow nutsedge (*Cyperus esculentus*). Weed Sci. 52:213–216.
Farris, R.L., C.J. Gray, D.S. Murray, and L.M. Verhalen. 2005. Time of removal of crownbeard (*Verbesina encelioides*) on peanut yield. Weed Technol. 19:380–384.
Ferrell, J.A., H.J. Earl, and W.K. Vencill. 2003. The effect of selected herbicides on CO_2 assimilation, chlorophyll fluorescence, and stomatal conductance in johnsongrass (*Sorghum halepense* L.). Weed Sci. 51:28–31.
Ferrell, J.A., H.J. Earl, and W.K. Vencill. 2004. Duration of yellow nutsedge (*Cyperus esculentus*) competitiveness after herbicide treatment. Weed Sci. 52:24–27.
Flanders, J.T. 2005. Tropical spiderwort: perspectives from a confused county agent. *In* Proceedings of the Tropical Spiderwort Symposium, Tifton, GA, November 29, 2005. http://www.cropsoil.uga.edu/weedsci/tsw2005/index.html. Accessed: February 14, 2007.
Forcella, F. 1997. My view. Weed Sci. 45:327–327.
Gonzalez, C.B. and C.R.B. Haddad. 1995. Light and temperature effects on flowering and seed germination of *Commelina Bengalensis* L. Arq. Biol. Tecnol. 38:651–659.
Hackett, N.M., D.S. Murray, and D.L. Weeks. 1987. Interference of horsenettle (*Solanum carolinense*) with peanuts (*Arachis hypogaea*). Weed Sci. 35:780–784.
Halford, C., A.S. Hamill, J. Zhang, and C. Doucet. 2001. Critical period of weed control in no-till soybean (*Glycine max*) and corn (*Zea mays*). Weed Technol. 15:737–744.
Harker, K.N., R.E. Blackshaw, and G.W. Clayton. 2001. Timing weed removal in field pea (*Pisum sativum*). Weed Technol. 15:277–283.
Hauser, E.W., G.A. Buchanan, and W.J. Ethredge. 1975. Competition of Florida beggarweed and sicklepod with peanuts. I. Effects of periods of weed-free maintenance or weed competition. Weed Sci. 23:368–372.
Holm, L.G., D.L. Plucknett, J.V. Pancho, and J.P. Herberger. 1977. *The World's Worst Weeds: Distribution and Biology*. Honolulu, HI: University Press of Hawaii.
Hoogenboom, G. 2006. Georgia automated environmental monitoring network University of Georgia, Griffin, GA. http://www.Georgiaweather.net. Accessed: April 24, 2006.
Kaul, V., N. Sharma, and A.K. Koul. 2002. Reproductive effort and sex allocation strategy in *Commelina Bengalensis* L., a common monsoon weed. Bot. J. Linn. Soc. 140:403–413.
Knezevic, S.Z., S.P. Evans, E.E. Blankenship, R.C. Van Acker, and J.L. Lindquist. 2002. Critical period for weed control: the concept and data analysis. Weed Sci. 50:773–786.
Knezevic, S.Z., S.P. Evans, and M. Mainz. 2003. Row spacing influences the critical timing for weed removal in soybean (*Glycine max*). Weed Technol. 17:666–673.
Kucharek, T.A., D.E. Purcifull, and R.G. Christie. 1998. The association of severe epidemics of cucumber mosaic in commercial fields of pepper and tobacco in north Florida with inoculum in *Commelina Bengalensis* and *C. communis*. Plant Dis. 82:1172.
Lopez-Ovejero, R.F., A.G.Y. Garcia, S.J.P. de Carvalho, P.J. Christoffoleti, D.D. Neto, F. Martins, and M. Nicolai. 2005. Using thermal units for estimating critical period of weed competition in off-season maize crop. J. Environ. Sci. Health Part B Pestic. Food Contam. Agric. Wastes 40:1–11.
Main, C.L., T.C. Mueller, R.M. Hayes, and J.B. Wilkerson. 2004. Response of selected horseweed (*Conyza canadensis* (L.) cronq.) populations to glyphosate. J. Agric. Food Chem. 52:879–883.
Martin, S.G., R.C. Van Acker, and L.F. Friesen. 2001. Critical period of weed control in spring canola. Weed Sci. 49:326–333.
Mbwana, A.S.S., S.W. Waudo, and K.V. Seshu-Reddy. 1995. Host-range of the lesion nematode, *Pratylenchus goodeyi*, commonly found in highland bananas of East Africa. Int. J. Pest Manag. 41:46–49.
Mueller, T.C., P.D. Mitchell, B.G. Young, and A.S. Culpepper. 2005. Proactive versus reactive management of glyphosate-resistant or -tolerant weeds. Weed Technol. 19:924–933.
Narendra, D.V. and V.G. Rao. 1973. New leaf-spot disease of *Commelina*, *Commelina Bengalensis* L (F- Commelinaceae). Curr. Sci. 42:180.
Ngouajio, M., J. Foko, and D. Fouejio. 1997. The critical period of weed control in common bean (*Phaseolus vulgaris* L.) in Cameroon. Crop Prot. 16:127–133.
Norsworthy, J.K. and M.J. Oliveira. 2004. Comparison of the critical period for weed control in wide- and narrow-row corn. Weed Sci. 52:802–807.
Paulo, E.M., F.S. Kasai, and J.C. Cavichioli. 2001. Effects of weed competition periods on peanut: II. Wet season crop. Bragantia 60:27–33.
Prostko, E.P., J. Baldwin, J. Beasely, T. Brenneman, S.L. Brown, G. Harris, K. Harrison, B. Kemeratit, N. Smith, and J. Williams. 2005a. 2005 Georgia Peanut Update. Tifton, GA: University of Georgia Cooperative Extension Service. http://commodities.caes.uga.edu/fieldcrops/Peanuts/pu2005/index.htm. Accessed: December 2, 2005).
Prostko, E.P., A.S. Culpepper, T.M. Webster, and J.T. Flanders. 2005b. Tropical spiderwort identification and control in Georgia field crops. Tifton, GA: University of Georgia Cooperative Extension Service Bulletin. http://pubs.caes.uga.edu/caespubs/pubs/PDF/c884.pdf.
Royal, S.S., B.J. Brecke, and D.L. Colvin. 1997a. Common cocklebur (*Xanthium strumarium*) interference with peanut (*Arachis hypogaea*). Weed Sci. 45:38–43.
Royal, S.S., B.J. Brecke, F.M. Shokes, and D.L. Colvin. 1997b. Influence of broadleaf weeds on chlorothalonil deposition, foliar disease incidence, and peanut (*Arachis hypogaea*) yield. Weed Technol. 11:51–58.
Spader, V. and R.A. Vidal. 2000. Response curve of *Commelina Bengalensis* to EPSPS enzyme inhibitory herbicides. Pest. Rev. Tec. Cient. 10:125–135.
Viator, R.P., R.C. Nuti, K.L. Edmisten, and R. Wells. 2005. Predicting cotton boll maturation period using degree days and other climatic factors. Agron. J. 97:494–499.
Walker, R.H., L.W. Wells, and J.A. McGuire. 1989. Bristly starbur (*Acanthospermum hispidum*) interference in peanuts (*Arachis hypogaea*). Weed Sci. 37:196–200.
Walker, S.R. and J.P. Evenson. 1985a. Biology of *Commelina Bengalensis* L. in south-eastern Queensland. 1. Growth, development and seed production. Weed Res. 25:239–244.
Walker, S.R. and J.P. Evenson. 1985b. Biology of *Commelina Bengalensis* L. in south-eastern Queensland. 2. Seed dormancy, germination and emergence. Weed Res. 25:245–250.
Webster, T.M. 2005. Weed survey—southern states: broadleaf crops subsection. Pages 291–306 *in* W.K. Vencill, ed. Proceedings of the Southern Weed Science Society. Volume 58.
Webster, T.M., M.G. Burton, A.S. Culpepper, J.T. Flanders, T.L. Grey, and A.C. York. 2006. Tropical spiderwort (*Commelina Bengalensis*) control and emergence patterns in preemergence herbicide systems. J. Cotton Sci. 10:68–75.
Webster, T.M., M.G. Burton, A.S. Culpepper, A.C. York, and E.P. Prostko. 2005a. Tropical spiderwort (*Commelina Bengalensis*): a tropical invader threatens agroecosystems of the southern United States. Weed Technol. 19:501–508.
Webster, T.M., A.S. Culpepper, J.T. Flanders, and T.L. Grey. 2005b. Planting date affects critical tropical spiderwort (*Commelina Bengalensis*)-free interval in cotton. Pages 2842–2843 *in* T.L. Grey, ed. Proceedings of the Beltwide Cotton Conference, Cotton Weed Science Research Conference, New Orleans.
Webster, T.M., A.S. Culpepper, T.L. Grey, J.T. Flanders, M.G. Burton, and A.C. York. 2004. Emergence patterns of tropical spiderwort (*Commelina Bengalensis*) in cotton. Proc. South. Weed Sci. Soc. 57:228–229.
Wilson, A.K. 1981. Commelinaceae—a review of the distribution, biology and control of the important weeds belonging to this family. Tropical Pest Manag. 27:405–418.
Zhang, W., E.P. Webster, D.Y. Lanclos, and J.P. Geaghan. 2003. Effect of weed interference duration and weed-free period on glufosinate-resistant rice (*Oryza sativa*). Weed Technol. 17:876–880.

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